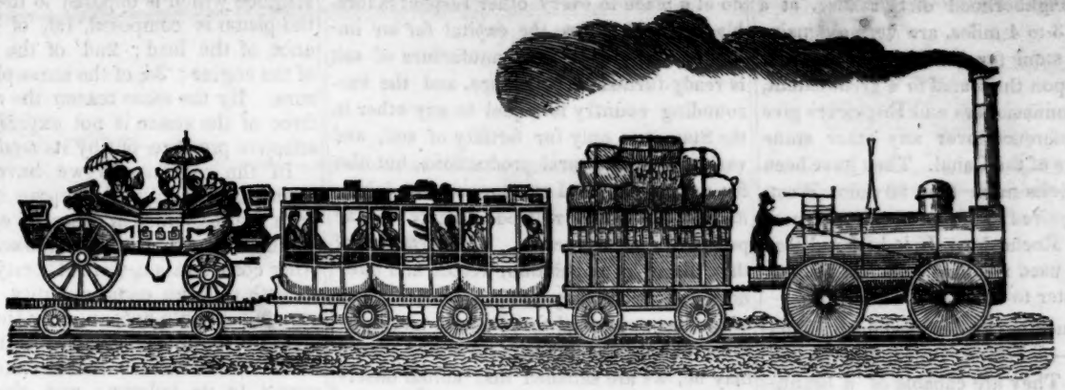

AMERICAN RAILROAD JOURNAL,

AND ADVOCATE OF INTERNAL IMPROVEMENTS.

PUBLISHED WEEKLY, AT NO. 132 NASSAU STREET, NEW-YORK, AT FIVE DOLLARS PER ANNUM, PAYABLE IN ADVANCE.

D. K MINOR, Editor.] SATURDAY, JUNE 11, 1836. [VOLUME V.—No. 23.

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AMERICAN RAILROAD JOURNAL.

NEW-YORK, JUNE 11, 1836.

At the annual election of Directors for the Hudson and Berkshire Railroad Company, the following named gentlemen were elected:—

James Mellen, John Delafield, Governeur Kemble, Rufus Reed, Oliver Wiswall, Ambrose L. Jordan, Charles B. Boynton, Samuel Anable, Elihu Gifford, William A. Dean, Robert A. Barnard, Silas Sprague, and Seneca Butts.

At a subsequent meeting, the Board elected James Mellen for their President, Elihu Gifford, Vice President, Levi A. Coffin, Treasurer, and J. W. Fairfield, Secretary.

RAILROADS FROM SYRACUSE.

At the last session of the Legislature, Railroads were incorporated radiating in almost all directions from Syracuse, in the county of Onondaga. Perhaps there is no point in the State so prominent for the intersection of Railroads, from opposite directions, as this. It is very central, and from the south line of the State to the St. Lawrence River, through this point, there will be a line of continuous Railways, of at least 160 miles in length, crossing the Railroad from Buffalo to Albany. Syracuse is equi-distant (150 miles) from Albany and Buffalo. It is also about central between the south line of the State, and the St. Lawrence River.

The Auburn and Syracuse Railroad, 25 miles in length, with a capital of $400,000 all subscribed, is now in the course of construction, and will be completed next year.

This is a part of the great Western Road to Buffalo. It commences at Auburn, a flourishing village, 7 miles from the canal, and passes through a fertile, wealthy, and populous district, to Syracuse. The transportation of property alone over this Road, consisting of that which is to be shipped upon the Canal, at Syracuse, and the merchandize for Auburn, and the county south of it, which will leave the Canal at its commencement, will, furnish a business that would warrant the construction of the Road, exclusive of passengers. The same remarks may also be made in relation to passengers. Should the prospective number of passengers be estimated only as they actually have increased, for a few years past, that business alone will be ample to pay 7 per cent. upon the capital. But the continued throng of travellers from Buffalo to Albany, increasing in numbers proportioned to the extent of country, and the rapidly increasing population of the West; aided by the facilities which Railroads will offer, will soon, like the Erie Canal, task this line to its utmost capacity; making the stock among the most desirable in the market; and the village—or *city*, as it soon will be—of Syracuse, one of the most populous and flourishing west of the Hudson river.

From Syracuse to Utica, a distance of from 50 to 54 miles, a Railroad has been authorised, and the stock is soon to be offered. The capital is $800,000. The Canal, passing through the upper part of Utica, is without a lock between the two places, though within the village of Syracuse, there is a lockage of 26 feet. This Road is to connect with the *Utica and Schenectady*, and the *Auburn and Syracuse Railroads*.

Probably there is not a foot difference in the elevation between the two ends of the Road, and at no intermediate point is it necessary to make any rise, unless it may be the trifling elevation necessary to cross the Canal. It is the most favorable route in the State for cheapness of construction, and for making a good Road. With no large streams to cross; no hazard of high water to injure embankments; it is over an extended plain, within a convenient distance of the Canal, having all the facilities of that channel for the transportation of materials, it must be unsurpassed as a useful public road, and its stock must always stand high. This Road has the privilege of carrying freight as well as passengers. The enormous subscription to the Utica and Schenectady Road, and the steady premium which its stock has sustained, shows the confidence which the public entertain of it as an investment, and, of consequence, its immense advantage, although it is not permitted to carry freight except during the winter.

Favorable as may be the opinion of that Road, it is believed that the Syracuse and Utica should equal it in public confidence, and that it will afford a return equal to any other.

From Syracuse to Brewerton, at the foot of Oneida Lake, a distance of 14 miles north, a Railroad has been chartered with a capital of $80,000. The books of subscription have not been opened. This is on the direct route from Syracuse to Watertown, and Cape Vincent, the former of which is but 65 miles distant. The route of this Road is highly favorable, and it is believed that it can be constructed at an expense not exceeding its capital. That it will be extended to Watertown and the St. Lawrence River, there is not a doubt.

In the neighborhood of Syracuse, at a distance of 3 to 4 miles, are very extensive quarries of stone for building. They have been used upon the Canal to a great extent, and the Commissioners and Engineers give them a preference over any other stone upon the line of the Canal. They have been taken for locks more than 60 miles West, and are *required* to be used for the new aqueduct at Rochester. It is believed that they will be used for the locks and bridges from Rochester to Utica.

These stones have been used for building in Oswego—in Lyons, Ithica, Owego and Rochester. They are capable of a beautiful polish, and some highly finished articles have been made of them.

To these quarries two Railroads have been chartered with a capital each of $75,000. The stone required to be used on the canal will pay the cost of a Railroad to the quarries, and the good quality of the stone for building, will ensure full employment for the Railway.

From Syracuse to Binghamton, a distance of about 70 miles, a Railroad has been chartered with a capital of $500,000. This road is intended to connect with the New-York and Erie Railroad at Binghamton. It will follow the valley of the Onondaga Creek and the Tioughnioga branch of the Chenango River, and will be very straight. The country through which it will pass is highly favorable for its construction. A glance at the map of the State will show that at no point can a road diverge from the Erie Railroad to the canal with greater advantage than from *Binghamton*. Whatever advantages there may be in the Erie Railroad, in affording a convenient way of reaching the city of New-York, they all go to aid the Syracuse and Binghamton road. There is also a charter granted for a Railroad from *Owego*, at the head of navigation on the Susquehannah River, to Courtland Village; there to intersect the road from Binghamton, thus opening an easy communication both with the eastern and westtern divisions of the New-York and Erie Railroad, and at the same time with the valley of the Susquehannah, in Pennsylvania and of course with Washington city. By a reference to the map, it will be perceived that the most direct and natural route from Lake Ontario, at Oswego, to the city of Washington, is through Syracuse, Courtland Village, Owego, and thence down the Valley of the Susquehannah river—and also to New-York, the same route will be used to Courtland Village, where a branch will diverge to the New-York and Erie Railroad, at Binghampton, thus making *Syracuse* the most central point of business; and its own immense resources beneath the soil of salt, plaster, and hydraulic cement, will make it, and at an early day, one of the most business-like places in the interior of the State.

That these roads will soon be completed there is no question, and meeting as they do at a place in every other respect favorably situated, where the capital for an immense business in the manufacture of salt is ready furnished by nature, and the surrounding country is equal to any other in the State, not only for fertility of soil, and variety of agricultural productions, but also for tho industry and enterprise of its inhabitants; all which will add largely to the prosperity of Syracuse. The advance of this place in population, wealth and business has been steady and progressive. Real estate has continued to advance, and however inviting for investment other places may be, we are satisfied that actual observations will convince any intelligent man that Syracuse must become one among the largest, if not the largest, of the interior towns in the State.

MARBLE CEMENT.

An important improvement, which has been for several years in progress, is about being introduced to the more general notice of the public, and we believe into extensive use for building purposes. It is a composition or cement, of which the principal ingredient is marble or lime stone, which, when applied to the inner or outer walls of buildings, presents the appearance of polished marble, of the various hues and qualities which distinguish the beautiful material imitated. What would be thought of a magician who possessed the power of changing the sombre brick and stone walls of the buildings of a city, in one week, into substances resembling the most beautiful Grecian, Italian, Egyptian or Verd Antique Marble, or porphyry, like the rock of Gibraltar? Yet all this may be done by this invention of a humble citizen, of Orange county, in this State. This cement has been sufficiently tested by experiments on buildings, to satisfy practical men of its decided superiority over any other cement, stucco, or other hard finish for walls, hitherto known. In our next number we expect to be able to furnish the public with some interesting particulars, on this subject; and in the mean time we can state, that a company has been formed, in this city, to carry on the operations connected with the manufacture of this new cement, and its application to buildings. Those who are curious in these matters, may obtain further information in relation to it, by applying at this office, or at the office of Edwin Williams, over Leavitt, Lord & Co., Broadway.

PAMBOUR ON LOCOMOTION.

Continued from page 328.

CHAPTER V.

ARTICLE II.

OF THE RESISTANCE ON THE PISTON OWING TO A GIVEN LOAD.

We have already explained that when a load is attached to an engine, the *total* resistance which is opposed to the motion of the piston is composed, 1st, of the resistance of the load; 2nd, of the resistance of the engine; 3d, of the atmospheric pressure. By the same reason the *real* elastic force of the steam is not expressed by its effective pressure, but by its *total* pressure.

In the calculations we have hitherto made, having only to compare the power with the ressitance in cases of equality or equilibrium, and without admixture of any other consideration, were at liberty to deduct on both sides an equal quantity, that is to say, to take into account only the effective pressure, and the effective resistance. But now we shall have to consider the steam in regard to its volume; and, that volume being determined by the *total* pressure, we must keep that expression of the elastic force as well as the one which corresponds with it for the resisting force.

Thus the resistance on the piston is composed of the three resistances, of the load, the engine and the atmosphere. Of these three forces, that which is owing to the atmospheric pressure is exerted immediately and directly on the piston. It must therefore be moved with the same velocity as the piston itself. But with the two others it is different. We have already seen that, in a machine, the pressures produced on different points are in an inverse ratio to the velocity of those points. Here, the engine and its train require to be moved with a velocity greater than that of the piston, in the proportion of the circumference of the wheel to twice the length of the stroke. The intenseness of the pressure produced on the piston, by the resistance of the load and that of the engine, is therefore greater than those same resistances in the above-mentioned proportion of the velocity of the wheel to that of the piston.

Supposing M to represent the number of tons composing the total load, tender included, and n the resistance per ton, nM will be the resistance of the train. If besides F expresses the friction or resistance of the engine without load, and δ the additional friction per unit of load, $F + \delta M$ will be the friction of the engine at the moment it draws the load M.

Thus,—

$$F + \delta M + nM$$

will be the resistance opposed to the progress along the rails by the engine and its train.

This force producing on the piston a resistance augmented in the proportion of the circumference of the wheel, to twice the stroke of the piston, if D be the diameter of the wheel, l the length of the stroke, and π the ratio of the circumference to the diameter,

$$(F + \delta M + nM)\frac{\pi D}{2l}$$

will be the resistance on the piston owing of that force; that is to say, to the friction to the engine and its train.

In the same way, representing by d the diameter of the cylinder, $\frac{1}{4}\pi d^2$ will be the area of the two pistons, and

$$\frac{(F + \delta M + nM)\frac{\pi D}{2l}}{\frac{1}{4}\pi d^2},$$

or

Fig. 13.

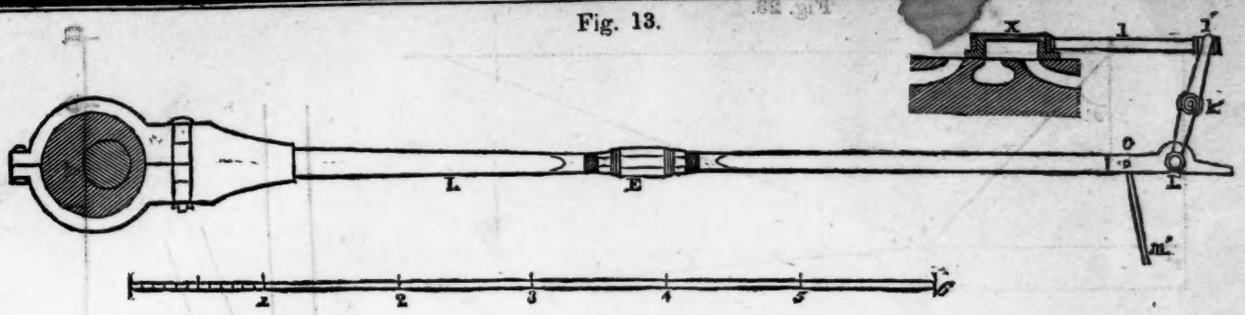


Fig. 14.

Fig. 15.

Scale for Figs. 15, 16, 17, and 19.

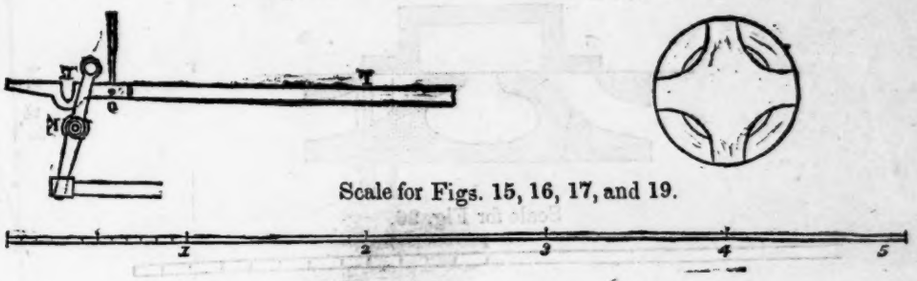


Fig. 16.

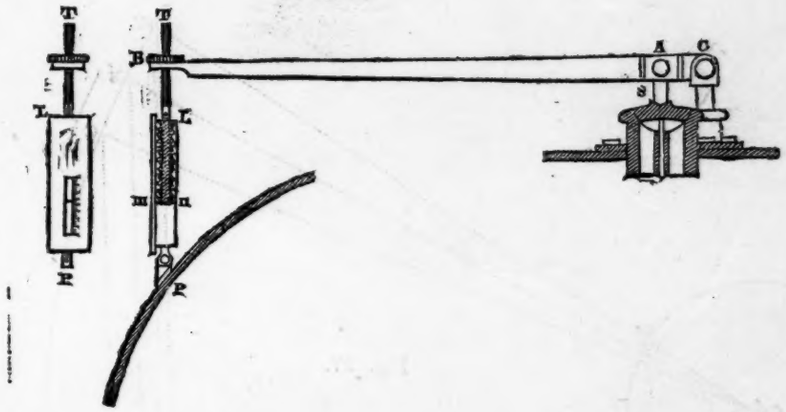


Fig. 19.

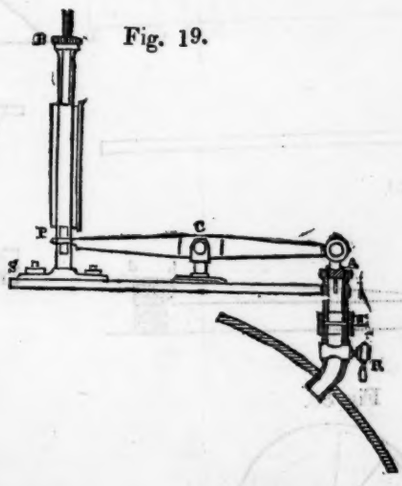


Fig. 17.

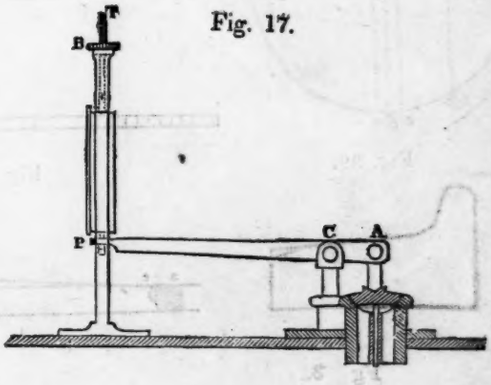
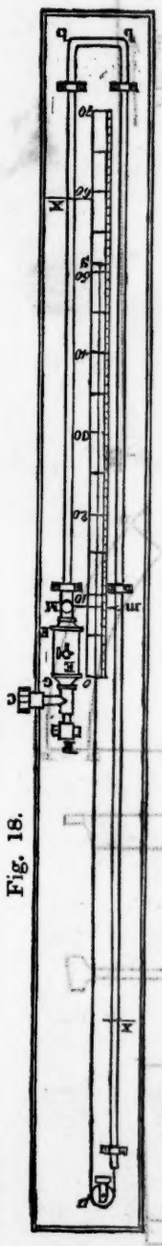


Fig. 18.



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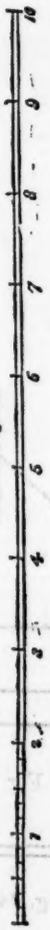


Fig. 20.

Fig. 21.

Fig. 22.

Fig. 23.

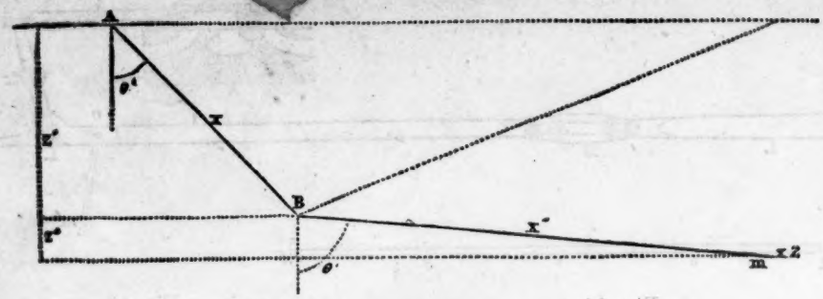
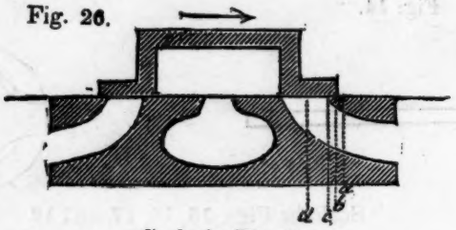


Fig. 26.



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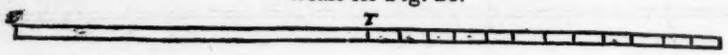


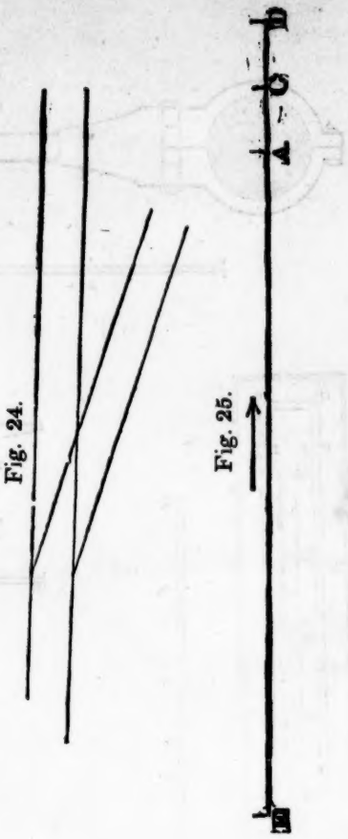


Fig. 24.

Fig. 25.

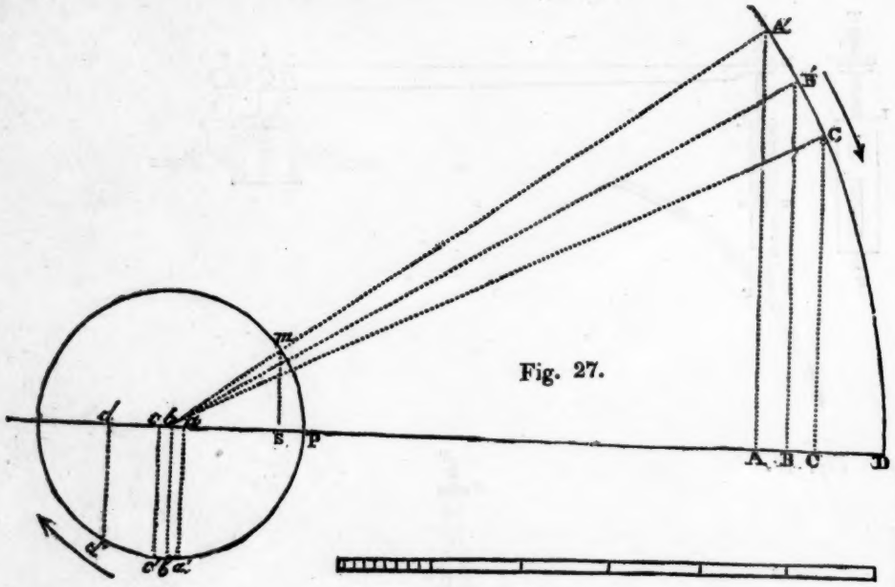


Fig. 27.

Fig. 28.

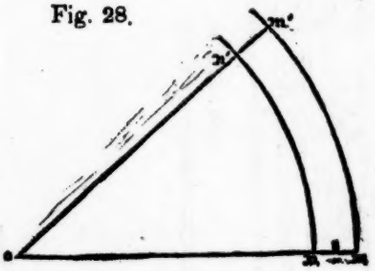


Fig. 29.

Fig. 30.

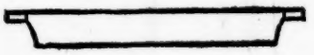
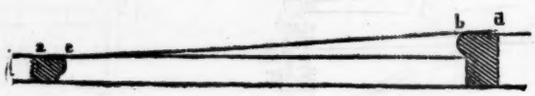


Fig. 31.

Fig. 32.



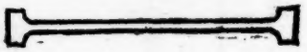


Fig. 34.

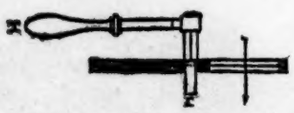
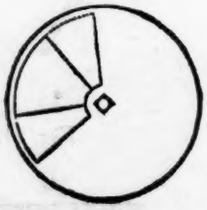


Fig. 33.



$$(F + \delta M + nM)\frac{D}{d^2 l}$$

will be the same force divided over the piston per unit of surface.

Adding to it, therefore, the atmospheric pressure per unit of surface, which we shall represent by ρ, we shall finally have, for the total pressure, owing to the resistance,

$$R = (F + \delta M + n M)\frac{D}{d^2 l} + \rho.$$

In this equation M is the weight of the load in tons, n is equal to 8 lbs. and $\delta = 1$ lb. D, l and d are expressed in inches, F and ρ in pounds; thus the value of R, when found, is the pressure resulting on the piston, in pounds per square inch.

The quantities D, l and d might also be expressed in feet, and ρ in lbs. per square foot. In that case, the value of R, when found, will be the pressure per square foot on the piston. This way of expressing the resistance comes exactly to the same as the preceding one, and is sometimes more convenient for calculation.

Applying this to a load of 100 t., drawn by an engine with cylinders of 11 in. diameter, stroke 16 in., wheel 5 ft., friction 110 lbs., we have,—

100 × 8 lbs. = 800 lbs. resistance of the train in lbs.
110 lbs. friction of the engine without load.
100 lbs. additional friction, owing to the load.

1010 lbs. total resistance to the progressive motion of the wheels.

3.1416 × 60in. = 188.50 in. cirumference of the wheel expressed in inches.

2 × 16 in. = 32 in. double of the stroke.

$\frac{188.5}{32} = 5.887$, ratio of the velocity of the wheel and of the piston.

Thus 1010 lbs. + 5.887 = 6,946 lbs. ressistance produced on the piston.

Besides $\frac{3.1416 \times 11^2}{2} = 190$ in. area of the two pistons in square inches.

Thus $\frac{5946 \text{ lbs.}}{190} = 31.2$ lbs. resistance on the piston, divided over each square inch of its surface.

And, lastly 31.2 lbs. + 14.7 lbs. = 46 lbs. final resistance per unit of surface of the piston of an engine with cylinders of 11 in. diameter, &c. drawing a load of 100 gross tons, tender included.

ARTICLE III.

OF THE PRESSURE IN THE CYLINDER.

The resistance on the piston being known, we may deduce from it the pressure of the steam, at the instant it acts as a moving power in the cylinder. It is sufficient for that to observe what passes during the motion.

The steam, being at first shut up in the boiler at any degree of pressure, passes into the steam-pipes and from thence into the cylinders. When it arrives in those cylinders, the area of which is about ten times as great as that of the pipes, the steam must necessarily expand and lose in the same proportion of its elastic force. However, the piston is still immovable; so that the steam continuing to arrive rapidly, the equilibrium of pressure is quickly established between the boiler and the cylinder. The pressure then becomes the same in the two vessels, and the piston being impelled by the force of the steam, begins slowly to move. The motion is communicated to the engine and to its whole train, and the mass gets a certain speed. This acquired speed continuing a little longer than the cause which produced it, the consequence is, that, at the following stroke, the steam finds the piston already slowly driven in a retrogade direction, at the moment when it gives it a fresh impulse, which in its turn is communicated to the total mass, where it continues to accumulate. Thus, receiving at each stroke a fresh impulse, while it still keeps the preceding one, the piston accelerates, by degrees, its speed, and the train finally acquires all the velocity the engine is able to communicate to it.

We have said that, at the beginning of the motion, an equilibrium of pressure is established between the boiler and the cylinder; but, in proportion as the velocity of the piston increases, this piston recedes, in a way, before the steam, without giving it sufficient time to establish the equilibrium, so that the pressure in the cylinder must necessarily diminish.

Nevertheless, the increase of the velocity and the diminution of the pressure have their limits. It is observed in every machine that the speed, at first very small, increases by degrees, as we have said, but only to a certain point which it never passes, the moving power not being capable of a greater speed with the mass to be moved. If the machine is well constructed, and particularly if it is regulated by a fly-wheel, the velocity once acquired is maintained without alteration, although the action of the moving power may continue to vary or to oscillate between certain limits, and the motion becomes perfectly uniform.

In the engines we consider, the mass of the train itself acts the part of a fly-wheel. That mass receives and stores up, in a manner, the additional velocity produced by the moving power at the time of its greatest action, in order to refund it afterwards, whenever the moving power happens to be in a moment of less force. It is from the difficulty of increasing and also of diminishing the speed of the mass, that the uniform motion results.

In regard to certain points of the engine, which, like the piston for instance, must necessarily vary in velocity during their oscillations, the uniformity of which we are speaking, consists in an exact periodical motion, which causes the velocity at each point of an oscillation to be precisely the same as it was at the same point of the preceding one. The result of this is, that if we take the duration of one of these oscillations as the unit of time, the motion will be strictly uniform.

As soon as the motion has acquired uniformity, which always takes place after a very short time and which is the regular state of the engine while travelling, the moving power, which at the beginning o the motion, was obliged to make an effort necessarily greater than the resistance, needs at present only to expend a force just sufficient to keep the resistance in equilibrium. For, if the moving power were to apply a greater or smaller force, the motion would be either accelerated or retarded, whilst, in fact, it is uniform.

From that moment, consequently, the pressure of the steam *in the cylinder*, which is the effort applied by the moving power, must be equal to the pressure of the resistance against the piston, which is the effort made by the resistance. This principle has been already demonstrated less extensively in another place.

We know thus the pressure at which the steam is expended by the cylinder, and as we also know the volume of the cylinder, we shall be able from both to conclude the absolute expense of power which takes place at each stroke of the piston. It is that expense, which, compared with the total mass of steam of which the engine can dispose, will give us, without any difficulty, the means of determing the velocity of the motion.

—

ARTICLE IV.

OF THE EVAPORATING POWER OF THE ENGINES.

§ 1. *Experiments on the Evaporating Power of the Engines.*

We have yet to determine the chief element of the question, viz. the evaporating power of the engines or the quantity of water they are able to transform into steam, under a determined pressure, in a given time.

With that view we undertook a series of experiments on the quantity of water evaporated by the engines of the Liverpool and Manchester Railway, during their journey from one of those towns to the other.

All the tenders on that Railway having exactly the same dimensions and an uniform shape, one of them was weighed, first empty and then loaded, whereby was ascertained that every inch of water in the tank corresponded exactly with a weight of 206.5 lbs. Then we proceeded in the following manner:—

We first ascertained, by means of the glass tube, at what height the water stood in the boiler at the moment of starting; and then we also measured the exact height of

the water in the tender. At the end of the journey, or at the intermediate station, if the engine stopped to take in fresh water, we first filled the boiler to the same height where it stood before setting off, and then we measured the water remaining in the tender. The difference between the height in the tender gave the consumption of water during the journey.

When describing these experiments, in order that the reader may see at once before him all the elements that have any importance in the question, we shall give the load of the engine, the time it took to complete the journey, which shows the velocity, the distance being 29½ miles, the state of the spring-balance from which the pressure results, and finally the temperature of the water in the tender at the moment of starting. We shall explain hereafter the column containing the total rising of the valve, which would permit all the steam generated in the boiler to escape.

In those experiments, we have mentioned the state of temperature of the water in the tender, because that circumstance must more or less facilitate the generation of steam, as it is easier to bring to the boiling point water already warm than cold water. However, as the temperature we mark in the tender, exists only at the moment of starting, and as it can remain thus only during a very small part of the journey, which lasts an hour and a half to two hours, it really has but a very inconsiderable influence on the result, of which the above experiments are, besides, sufficient proof.

We have also set down the pressure under which the steam was generated in each experiment. Water not being able to evaporate under a high pressure, unless by means of a higher temperature, we have reason to suppose that, *cæteris paribus*, the engine must be able to evaporate less water under a more considerable pressure. But as we shall see below, in a table we shall give on the volume and temperature of the steam, that between the degrees of pressure at which the engines constantly work, viz. between 50 and 60 lbs. effective pressure per square inch, the difference of temperature is only nine degrees by the thermometer, or 4½ degrees difference for the mean pressure, we shall easily be convinced that the influence of the pressure on the quantity of water evaporated must be almost imperceptible. Besides, when we employ a less elevated pressure, the steam generated under that pressure occupies more space, the boiler is too small to contain it, and the valve is consequently more subject to blow. The result is, that the engineman accustomed to regulate himself by the valve, seeing it continually blow, does not animate his fire so much as in the case where the valve is fixed at a higher pressure. The circumstance, therefore compensates for the former one, and frequently surpasses it.

We see, consequently, in the related experiments, that the speed is the only thing that has a constant and perceptible effect on the generation of steam.

The cause of this effect of the speed is, that in those engines the steam, in issuing from the cylinders, is conducted to the chimney, where it creates an artificial current of air, and acts exactly in the same manner as the bellows in giving activity to the fire. Every jet of steam represents a stroke of the bellows; and it is consequently clear, that the more rapid the motion of the engine, the more cylinders of steam will be thrown into the chimney in a minute, and the more violently also will the fire be excited.

By examining the experiments, we find, in fact, that the greater the velocity of the motion, the more considerable was the evaporation; and for that reason it is necessary, in endeavoring to determine the evaporating power of the engines, to take them at their average velocity.

The speed of 18½ miles per hour, which is the average speed of our experiments, fulfils tolerably well that condition for the Liverpool engines. We must, therefore, consider the corresponding evaporation, which was equal to 55.82 cubic feet per hour, as the average evaporation of the engines employed.

Nevertheless, we see that some of those engines have evaporated 60 or 62 cubic feet of water per hour, which makes a cubic foot per minute, or a pound of water per second.

§ 2. *Of the evaporating Power per unit of heating Surface.*

However, as the different engines that figured in the experiments differed in regard to their heating surface, we can determine precisely the evaporating power only, by comparing the effects of evaporation with

EXPERIMENTS ON THE EVAPORATING POWER OF THE ENGINES.

Number of the experiment.	DATE.	Name of the engine.	Load of the engine tender included	Water evaporated. In lbs.	Water evaporated. In cubic feet.	Total duration of the journey.	Delays on the road included in that time.	Average state of the spring-balance.	Rising of the valve sufficient to give issue to all the steam generated in the boiler.	Average effective pressure during the experiment in lbs. per square inch.	Temperature of the water in the tender at starting.	Velocity of the engine in miles per hour.	Evaporation per hour in each experiment.	Heating surface: Exposed to the action of radiating caloric.	Heating surface: Exposed to the action of communicative caloric.
	1834.		tons.	lbs.	cubic ft.	hours.				lbs.		miles.	cubic ft.	sq. feet.	sq. feet.
I.	July 22	Vulcan	39.07	4646	74.34	1.17′	3′	31...32.5	5	54.5	just lukewarm	22.99	57.92	34.45	307.38
II.	July 23	Atlas	195.50	8260	132.16	3.17	15	50...50.7	4	55.7	cold	8.99	40.25	57.06	217.88
III.	Aug. 4	—	127.64	5937	94.99	1.58	0	50...50.1	4	53	cold	15.00	48.30	—	—
IV.	July 31	—	40.15	5524	88.38	1.54	0	24...25.5	4	30	cold	15.53	46.52	—	—
V.	July 24	Fury	56.16	4578	78.05	1.30	0	31.2...32.6	5	57	cold	19.67	52.03	32.87	307.38
VI.	July 24	—	48.80	5446	87.14	1.35	0	31.2...32.7	5	57	cold	18.63	55.03	—	—
VII.	July 26	Firefly	41.40	6143	98.29	1.40	5	14.5...14.5	3	44	almost cold	17.70	58.97	43.91	362.60
VIII.	July 26	—	41.40	6040	96.64	1.23	5	16.6...17.3	3	49	lukewarm	21.33	69.56	—	—
IX.	Aug. 1	Vesta	33.15	4130	66.08	1.5	0	20. ...21.3	3½	51	very hot	27.23	61.00	46.00	256.08
X.	Aug. 15	Leeds	88.34	5989	95.82	1.35	0	31. ...32.2	5	54	just lukewarm	18.63	60.52	34.57	307.38
XI.	Aug. 15	—	37.51	5317	85.07	1.20½	3	26.5...28.5	5	49	very hot	21.99	63.41	—	—
										Means		18.88	55.82	43.12	288.35

the dimensions of the surface which produces them.

That is the object of the two last columns we added to the preceding table, which repeat the dimensions of the heating surfaces of the engines, so as they were given with more particulars in our first chapter (Chap. I. Art. II. § 3.)

By the mean results of those two columns we see that the average evaporation of 55.82 cubic feet of water, was produced by a heating surface consisting of 43.12 square feet exposed to the action of the radiating caloric, and 288.35 square feet exposed to the communicative heat. This is, therefore, the extent of evaporating surface to which we must refer the effect produced.

If we admit, in consequence of the experiment related in our first chapter (Chap. I. Art. II. § 3,) that each unit of surface exposed to the communicative heat produces the third part of the effect that same surface would produce if exposed to the radiating caloric, the heating surface above may be represented by 139.24 square feet exposed to the immediate or radiating action of the fire; and as those 139.24 square feet have produced in an hour the evaporation of 55.32 cubic feet, we see that each square foot has evaporated a volume of water expressed by 0.401 cubic foot.

Thus at a velocity of 18½ miles per hour, which is nearly the average speed of the engines, each square foot of heating surface, exposed to the radiating action of the fire, evaporates in an hour a volume of water of 0.401, or a little more than $\frac{4}{10}$ of a cubic foot. This is the expression of the *evaporating power of the engines per unit of heating surface.* Multiplying this, for each engine, by the extent of the heating surface, we shall find the total evaporating power of the engine.

§ 3. *Of the effective evaporating Power of the Engines.*

We must however remark, that although all that water is transformed into steam, there is only a part of it applied to the working of the engine. To be convinced of this fact, we need only examine the valves of the engines while working. We see them constantly emit a considerable quantity of steam, which, instead of entering the cylinders, escapes immediately into the atmosphere. This loss is a defect which it would perhaps not be difficult to correct, and, if corrected, would tend considerably towards an economy of fuel.

The plan in contemplation on the Liverpool Railway of replacing the present cylinders of the engines by others of a greater diameter, will at least have that advantage, that in case of considerable loads, it will render available all the steam generated in the boiler.

In the experiments of which we have given an account, not only is that loss perceptible, but it is even susceptible of being to a certain degree appreciated.

Under the head "*State of the Spring-balance,*" we have inscribed in the table above according to the observation in each experiment, the point of departure of the spring-balance, and the point at which it rose by blowing. The interval between these two degrees gives the rising of the valve that took place during the experiment, to which rising was owing the escaping of the steam. Thus, in the first experiment, the valve of the VULCAN fixed at 31 as point of departure, rose to 32½ by the blowing; consequently, the rising of the valve was of 1½ degree on the balance. The same for the others.

In the following column we have given the quantity of rising sufficient for the valve of each of the engines to give issue to all the steam the engines are able to generate. This point may have been already observed in our experiments on the pressure. We have seen, that whatever care be taken to animate the fire, the valve can never rise beyond a certain point, because then it gives issue to all the steam generated. An exact knowledge of this point was easy to acquire by observation in the numerous experiments on the velocity of the engines we are going to relate.

Thus we found, for instance, that the ATLAS engine, travelling at its greatest speed, and stopped all of a sudden, at the instant it was generating the most steam, raised its valve from 50 degress to 54 degrees; and that the passage resulting from that rising was sufficient to evacuate all the steam. In the same manner, the LEEDS, VULCAN, and FURY, raised in similar circumstances their valve from 31 to 36, VESTA from 20 to 23½, and FIREFLY from 17 to 20; the second valve of these engines being, besides, at the points indicated for them in our experiments on pressure. These degrees of rising naturally depend, 1st, on the quantity of steam generated by each engine, and the diameter of the valve; 2nd, on the dimensions of the levers and the size of the divisions of the balance, which makes a degree by the balance correspond with a greater or a lesser rising; and, lastly, on the second valve, which may give more or less issue to the steam.

These circumstances explain the differences that appear to exist between the engines. In the ATLAS, the second valve gave no issue to the steam, and the first was only 2½ in. in diameter; but the divisions of the balance of that engine being very great, on account of the proportions of the lever, four divisions of the balance are equal to a considerable rising of the valve, which was sufficient to evacuate the steam. In the LEEDS, VULCAN, and FURY, the second valve did not rise in the pressures we employed; but the first valve, which is the one we consider here, was 3 in. in diameter. In the VESTA, the second valve gave issue to the steam as well as the first; the consequence of which was, that a rising of 3.5 degrees of the balance was sufficient for the evacuation of the steam. Lastly, in the FIREFLY, only one of the valves blew, but at the time of the experiments that engine was in a very bad condition. Its boiler was leaky, the water ran out into the fire-place, where it evaporated, and a very small quantity of steam was really collected in the boiler.

Repeated experiments having, therefore-determined these points in a positive manner, it now becomes possible, with the elements we have at our disposal, to appreciate the quantity of steam that escaped during the above-mentioned experiments. It is sufficient for that to compare the two columns, one of which shows the rising that really took place, and the other the rising that would have been sufficient for the evacuation of all the steam. By that means, we shall find that the average rising that took place during the experiments was 12 on 46.5. A quarter of the steam was, therefore, lost through the valve—we might even say a little more, particularly considering that the FIREFLY engine was then in a bad condition—and lost some of its steam through the leaks of its boiler.

On the other hand, that loss of steam is not accidental, but inherent to the construction itself of those engines; and among all the experiments on the velocity that we shall relate below, there will scarcely be found a single instance in which that effect was not produced; and when it was not, the reason was that the fire was not excited to the highest possible degree. It is therefore necessary to establish a distinction between the evaporating power of the engine, and what we shall call their *effective* evaporating power; that is to say, the part of that power which is really applied to the working of the engine.

From the experiments above, we find that of all the steam generated in the boiler, three quarters only enter into the cylinders.

Thus, the evaporating power per square foot of heating surface exposed to the radiating caloric, having been found to be 0.401 cubic foot, the available part of it, or the *effective evaporating power expressed in cubic feet of water evaporated in an hour per square foot of surface, is* 0.301 *cubic foot, or* $\frac{3}{10}$ *of a cubic foot.*

Finally, returning to the mean of the above experiments, the evaporating power was in each hour 55.82 cubic feet; consequently, the *effective* evaporating power, taken as an average for all the engines, is 41.87 cubic feet.

—

ARTICLE V.

OF THE PROPORTIONS OF THE ENGINES, AND THEIR CORRESPONDING EFFECTS.

§ 1. *Analytical expression of the Velocity of the Engine with a given Load.*

With these elements it is easy to determine the velocity which an engine is able to acquire with a given load.

Supposing, for instance, we have a load of 100 t., tender included, attached to an engine with cylinders of 11 in. diameter, stroke 16 in., wheels 5 ft., friction 110 lbs., *effective* pressure of the steam in the boiler 50 lbs. per square inch, and finally effective evaporating power, such as we have found it for the average of the Liverpool engines, that is to say, 41.87 cubic feet of water evaporated in an hour.

We have already seen above (Chap. V. Art. II.,) that the *total* resistance which that load opposed to the motion of the pis-

ton in the case of that engine was 46 lbs. per square inch; and we have also seen that, in consequence of that resistance, the total pressure of the steam, when arriving in the cylinder, was also necessarily 46 lbs. per square inch.

The mass of water evaporated is 41.87 cubic feet per hour, or 0.70 cubic feet per minute. This water is immediately transformed, in the boiler, into steam, at the effective pressure of 50 lbs. per square inch or at the total pressure of 65 lbs. per square inch.

But we know the volume of the steam generated under a determined pressure. Tables of that volume have been formed from experiment, and one will be found below, § 11. According to these tables, the steam, generated under a total pressure of 65 lbs. per square inch, occupies 435 times the space of the water which produced it. Thus the water transformed into steam at the total pressure of 65 lbs. per square inch, and spent each minute in the motion, formed a volume of

$$0.70 \text{ c. ft.} \times 435 = 304 \text{ cubic feet.}$$

This steam, penetrating into the cylinders, is then reduced to a pressure of 46 lbs. Its temperature, however, remains the same, because the pipes that conduct it to the cylinders and the cylinders themselves are immersed in the boiler, or surrounded by the flame that comes out of the fire-place. We know that the space occupied by the steam, when its temperature remains the same, augments in an inverse ratio to the pressure. At the moment it arrives in the cylinders, that same mass of steam occupies consequently a greater space in the proportion of 65 to 46.

Thus its total volume is then

$$304 \times \frac{65}{46} = 430 \text{ cubic feet.}$$

Now, the area of the two cylinders is 190 square inches or 1.32 square foot; thus the above volume of 430 cubic feet of steam, passing through the cylinders in a minute, must necessarily cross them with a volocity of

$$\frac{430}{1.32} = 326 \text{ feet per minute.}$$

which gives us, consequently, the velocity of the piston in feet per minute with the supposed load.

To deduce from that the speed of the engine in miles per hour, we must observe that an hour contains 60 minutes, and thus that the speed per hour will be 60 times as great; a mile containing 5280 ft., the produce must be divided by that number in order to have the speed expressed in miles; and finally the speed of the engine, according to the proportion of the stroke to the diameter of the wheel, is 5.887 times that of the piston.

We shall consequently have

$$\frac{326 \times 60}{5280} \times 5.887 = 21.83 \text{ miles, velocity of}$$

the engine per hour.

Thus we see that the evaporation supposed above, must necessarily produce a velocity of 21¾ miles per hour for the engine; that is to say, that a locomotive, engine, with the above-mentioned proportions is able, if in a good condition and with a well-animated fire, to draw a load of 100 t., tender included, with a velocity of $21\frac{3}{4}$ miles an hour.

The same mode of calculation may serve for any other load or any other engine. Thus, in general, making again use of the letters already employed in our research of the resistance on the piston, viz.

M representing the number of tons of the load.

n the resistance of the load per ton.

F the friction of the engine without load.

δ its additional friction for each to of the load.

D the diameter of the wheel.

d the diameter of the cylinder.

l the length of the stroke.

And ρ the atmospheric pressure per unit of surface.

$$R = (F + \delta M + nM)\frac{D}{d^2 l} + \rho,$$

will be the pressure of the steam per unit of surface in the cylinder as above demonstrated (Chap V. Art. II.)

If, besides,

P express the total pressure of the steam in the boiler;

s, The effective evaporating power of the engine expressed by the number of cubic feet the boiler is able to evaporate in a minute at the pressure P,

And m the ratio of the volume of steam, at the degree of pressure P, to the volume of water,

$$m \times s$$

will be the total volume of steam generated in a minute at the pressure P of the boiler.

The steam, arriving in the cylinder passes from the pressure P to the pressure R, and changes its volume in an inverse ratio to the pressures; so that

$$ms \times \frac{P}{R}$$

is the space occupied by the steam when arrived in the cylinders.

This volume of steam, crossing the cylinders in a minute, if we divide it by the area of the cylinders, we shall have the speed it must necessarily have, and consequently the velocity it will communicate to the piston.

Now the area of the two cylinders is $\frac{1}{2}\pi d^2$; thus the velocity per minute will be,

$$\frac{ms\,P}{\frac{1}{2}\pi d^2 R}.$$

In order to effect that division, the area of the cylinders ought necessarily to be expressed in units similar to those of the volume s. The area of the cylinders must be then expressed in square feet and not in inches; and the same condition is consequently required also for R, P, and ρ. So in the calculation we must express the pressures in lbs. per square foot, which puts them at the same rate as if expressed in the usual manner.

Passing from this expression to the velocity of the engine, we know that it is to the velocity of the piston in the proportion of the circumference of the wheel to twice the stroke, thus the speed of the engine is

$$v = \frac{ms\,PD}{R\,d^2 l};$$

or, putting for R its value found above, and passing from the speed per minute to the speed per hour, in multiplying by 60,

$$V = 60\,\frac{ms\,PD}{(F + \delta M + nM)\,D + \rho d^2 l}.$$

It must be remarked that 60 s is equal to S, or the evaporating power *per hour*; that is to say, that by employing this value it is no longer necessary to multiply by 60, and the reckoning will be simplificd in its application.

The formula will then be,

$$V = \frac{m\,PSD}{[F + (\delta + n)M]\,D + \rho d^2 l}.$$

This will consequently be the general expression of the velocity of the engine per hour; expression in which everything is known by measures taken on the engine, even the evaporating power S, which results from the extent of the heating surface computed as above. m, which is the volume of the steam generated under the pressure P, is found in a table like the one below (Chap. V. Art. V. § 11.)

By means of this formula, and by measures simply taken on the engine, it will therefore be easy to determine immediately the effect we may expect from it.

In that expression, the evaporating power S being expressed in cubic feet the resulting speed will also be expressed in feet. If we wish to have it in miles, as a mile contains 2580 ft., it will be sufficient to divide by that number, and the result will be the speed of the engine in miles per hour.

We shall see further on that the produce mP is almost invariable; and consequently we learn by the inspection of this formula, that the velocity of an engine with a given lead increases with the heating surface and the diameter of the wheel, and diminishes, on the contrary, when the diameter of the cylinder and the stroke of the piston augment.

§ 2. *Analytical expression of the Load that an Engine can draw at a given Velocity.*

If, on the contrary, we wish to know the load a given engine can draw at a determined speed, it is sufficient, in the foregcing equation, to consider V as known and to draw from it the unknown quantity M.

It will then be,

$$M = \frac{m\,PSD - \rho d^2 l V}{(\delta + n)\,VD} - \frac{F}{\delta + n}.$$

After the manner that the calculation has been established, it is clear that the value we shall find for M, will be the number of tons of the *total* load, that is to say, tender included.

§ 3. *Of the Heating Surface that must be adopted to obtain from an Engine a determined Velocity with a given Load.*

The same equation may also serve to determine any one of the indeterminate quantities in the general problem of loco-

motive engines. Thus, for instance, it will show the extent of heating surface, or the evaporating power necessary to enable an engine to draw a known load at a fixed speed. For that, we have only to draw from the general equation the value of S.

It will be,

$$S = \frac{V\,[(\delta+)\,M\,D\,n\,F\,D + \rho\,d^2\,l]\,.}{m\,P\,D}$$

The result thus obtained will be the effective evaporating power of the engine in cubic feet of water per hour; and as we have seen (Chap. V. Art. IV. § 3) that the effective evaporating power is equal to $\frac{3}{10}$ of the heating surface expressed in square feet, we shall easily obtain the last by multiplying the result by the fractional number $\frac{10}{3}$.

§ 4. *Of the Maximum Load of an Engine with a given Pressure.*

We found above (§ 2) the expression of the load an engine is able to draw at a given velocity; and the less the velocity, the more considerable may be the load. We must, however, add that in all cases, for the motion to be possible, the resistance on the piston must not be greater than the force that is to move it. Consequently, the resistance we have expressed by R must, at most, be equal to P. This observation fixes the limits of the possible load, with a determined pressure. Beyond that point the equation may continue to give results, but they will no longer suit the question. The limit of the load with the pressure P will thus be known by the equation R = P; or,

$$[F + (\delta + n)\,M]\,\frac{D}{\rho\,d^2\,l} + \rho = P,$$

which gives

$$M = \frac{(P - \rho\,d^2\,l}{(\delta+n)\,D} - \frac{F}{\delta+n}$$

This equation will give the maximum load of the engine, including the weight of the tender, subservient, however, to the conditions of adhesion explained hereafter, in Chap. VIII.

§ 5. *Of the Velocity of the Engine corresponding with the Maximum Load.*

Putting that value of M in the formula that gives the speed, we have the speed corresponding with the maximum load. After the necessary reductions we find—

$$V = \frac{m\,S\,D}{d^4\,l}.$$

If we write this expression under the following form—

$$V \quad \frac{m\,S}{\frac{1}{2}\pi d^2} \times \frac{\pi\,D}{2l},$$

we shall perceive at first sight, that it is exactly the speed produced by the passage in the cylinders of the steam of the boiler, when that steam undergoes no reduction of pressure. In fact, $\frac{m\,S}{\frac{1}{2}\pi\,d^4}$ is the mass of steam produced *at the pressure of the boiler*, divided by the area of the two cylinders; that is to say, the speed which its passage in the cylinders, without alteration, produces for the piston; and multiplying that quantity by $\frac{\pi D}{2\,l}$ which is the proportion of the velocity of the engine to that of the piston, the result will naturally be the relative speed of the engine.

We also see that in the case of a maximum load, the pressure of the steam in the cylinder will be the same as in the boiler, and that its velocity will be the very velocity at which the steam is generated in the boiler; results which besides are, of themselves, evident to an attentive mind, and which have already been pointed out.

In regard to the limit of speed with small loads, the engine-men never urge it so as to risk an accident, by too great a velocity in the motion of the piston, or other parts of the mechanism. Only one single instance, in the experiments we shall relate below, will be found, in which the engines attained a speed of 35 miles an hour. This velocity is the greatest that has been observed, until the present moment, except during some extremely short intervals. When the train is too light, the engine-men take care partially to shut the regulator, and not to animate the fire to its highest pitch, as we shall mention hereafter.

§ 6. *Of the Diameter that ought to be given to the Cylinder, to render an Engine capable of attaining a fixed Maximum Load.*

The same equation from which we have concluded above (§ 4) the limit of possible loads with a given pressure, may also serve to determine the diameter that ought to be given to the cylinders of an engine to render it capable of drawing a fixed load at a certain pressure.

$$d = \sqrt{\frac{D\,[(\delta+n)\,M + F]}{(P-\rho)\,l}}.$$

This diameter will be expressed in feet, according to the manner the calculation was made. It will be easily reduced to the common expression in inches.

§ 7. *Of the Length that ought to be given to the Stroke of the Piston of an Engine, the Cylinders of which have already a fixed Diameter, so as to enable that Engine to draw a certain Maximum Load.*

In the same manner, also, if the diameter of the cylinder has already been chosen on account of some other consideration, we may, in a certain degree, produce the same effect; that is to say, render the engine able to attain the maximum load required, by adopting for the stroke of the piston a suitable length. In that case the equation gives—

$$l = \frac{D\,[(\delta+n)\,M + F]}{(P-\rho)\,d}.$$

This measure of the stroke will be expressed, according to the adopted measures, in feet and decimals of feet; one may transform it, as usual, in inches.

§ 8. *Of the Diameter that ought to be given to the Wheel of an Engine, so as to enable it to draw a fixed Maximum Load.*

We may also obtain the same result by reducing, in a suitable proportion, the diameter of the wheel, by which the speed of the engine will be diminished, and a greater power of traction given to it. The equation will, in that case, give for the diameter of the wheel—

$$D = \frac{(P-\rho)\,d^2\,l}{(\delta+n)\,M + F}.$$

It is understood that this method can only succeed within certain limits, and that the diameter of the wheel cannot be reduced beyond certain dimensions, fixed by the other requisites of the business.

§ 9. *Of the effective Pressure necessary in the Boiler of an Engine, the Dimensions of which are already fixed, in order that the Engine may draw a certain Maximum Load.*

Finally, if the length of the stroke, the diameter of the cylinders, and that of the wheel are already fixed, we may calculate what is the pressure that must be produced in the boiler to enable the engine to attain the maximum load required. The same equation resolved in that case, in regard to the quantity P considered as unknown, gives—

$$P - \rho = \frac{D\,[(\delta+n)\,M + F]}{d^2\,l}.$$

This pressure will be expressed, according to the adopted measures, in pounds per square foot, but, by taking the $\frac{1}{144}$ part of it, we may reduce it to the usual expression of pounds per square inch.

The same would take place in regard to any other research. These deductions are easily found;—we shall not stop any longer on this point. It is scarcely necessary to add, that the values given by those equations are only applicable to the questions, in as far as they are not in opposition to the practical rules of construction. Thus, the pressure determined above must in no case exceed the resistance of which the metal of the boiler is capable; neither must the diameter of the wheel be large enough to put the engine in danger in going off the rails, nor small enough to destroy its speed, &c. &c.

§ 10. *Synoptical Table of the preceding Formulæ.*

In a view to facilitate practical researches, we shall collect here those different forformulæ into a table.

The signs employed having the following significations, viz. :—

M, representing the number of gross tons of the load, tender included.

n, the resistance per ton of the load, or according to the determination already made, $n = 8$ lbs.

F, the friction of the engine without load, taken, according to the average of the above experiments, in case the engine is not yet constructed; that is to say, at 15 lbs. per ton of its presumed weight. In case the engine is already constructed, and one wishes to obtain a very accurate result, F must be determined by a direct experiment made on the engine itself.

δ, the additional friction of the engine per ton of load, or according to the determination hereabove, $\delta = 1$ lb.; and, consequently, $(\delta + n) = 9$ lbs.

D, the diameter of the wheel, expressed in feet,

d, the diameter of the cylinder, also expressed in feet and decimals of feet.

l, the length of the stroke, in feet and decimals of feet.

P, the *total* pressure (or atmospheric pressure included) of the steam in the boiler, expressed in pounds per square foot; that is to say, 144 times the pressure per square inch.

ρ, the atmospheric pressure expressed in pounds per square foot as above, that is to say, ρ = 2117 lbs.; and, consequently (P — ρ), the effective pressure of the steam in the boiler, being expressed in the same manner, viz., in pounds per square foot.

S, being the *effective* evaporating power of the engine per hour, or otherwise, according to the described experiments, S being the $\frac{3}{10}$ of the number of square feet in the *reduced* heating surface. (It will be recollected, that the *reduced* heating surface itself consists of the sum of the heating surface of the fire-place, more the third part of the heating surface of the tubes.)

m, being the ratio of the volume of the steam at the *total* pressure P, to the volume of water that has produced it, according to the known tables, one of which will be found in one of the following paragraphs.

V, finally, being the velocity of the engine in feet per hour, that velocity being necessarily expressed in that manner for the general harmony of the calculation; but as a mile contains 5280 feet, it can easily be reduced to the speed in miles, and *vice versa*.

These different signs being thus well understood, and the letters *n* and *δ* being replaced by their values, 8 lbs. and 1 lb., the formulæ above give the following table:—

SYNOPTICAL TABLE OF THE PRACTICAL FORMULÆ OF LOCOMOTIVE ENGINES.

QUESTIONS TO BE SOLVED.	FORMULÆ.
1. *Velocity* which an Engine of known proportions will take, when working at a given pressure, and drawing a determined load. The result being the speed in feet per hour, the speed in miles will be obtained by dividing by 5280:—	$V = \frac{m P S D}{(F + 9 M) D + \rho d^2 l}$
2. *Load* that a given Engine will be able to draw, with a known pressure, and at a determined velocity. This load will be expressed in gross tons, tender included:—	$M = \frac{m P S D - \rho d^2 l V}{9 V D} - \frac{F}{9}$.
3. *Heating Surface* that must be given to the boiler of an Engine, in order that it may draw a known load with a fixed velocity. The equation gives the effective evaporating power per hour, from which the heating surface may be deduced by multiplying by the fractional number $\frac{10}{3}$:—	$S = \frac{V[(9 M + F) D + \rho d^2 l]}{m P D}$.
4. *Maximum load* that an Engine is able to draw at a determined pressure. This load is expressed in gross tons, and includes the tender:—	$M = \frac{(P - \rho) d^2 l}{9 D} - \frac{F}{9}$.
5. *Velocity* of an Engine, with its *maximum* load. This speed being expressed in feet, the speed per mile will be its $\frac{1}{5280}$ part:—	$V = \frac{m S D}{d^2 l}$.
6. *Diameter* that must be given to the *cylinder* of an Engine not yet constructed, in order that, if necessary, it may draw a certain maximum load. The diameter being expressed in feet and decimals of feet, its expression in inches will be found in multiplying by 12:—	$d = \sqrt{\frac{D (9 M + F)}{(P - \rho) l}}$.
7. *Length of stroke of the Piston* that may replace the diameter of the cylinder and produce the same effect of maximum load. This stroke will be expressed in feet, and may be transformed into inches, as above:—	$l = \frac{D (9 M + F)}{(P - \rho) d^2}$.
8. *Diameter of the wheel* of an Engine, in order to render it able to draw the same maximun load:—	$D = \frac{(P - \rho) d^2 l}{9 M + F}$.
9. *Effective pressure* that must be produced in the boiler of a given Engine, in order to render that Engine capable of drawing a certain maximum load. This pressure being expressed in pounds per square foot, the pressure per inch will be its $\frac{1}{144}$.	$(P - \rho) = \frac{D (9 M + F)}{d^2 l}$.

We must remark that these formulæ are not such as are called *empiric* ones; that is to say, imaginary suppositions, corresponding more or less exactly with experience. They are, on the contrary, rigorous deductions from the most solid principles of mechanics; their elements have been determined by direct experiments, and their results will soon be confirmed in the same way.

In all cases, these formulæ suppose the engine drawing its load *on a dead level*. If it be required to apply them to the case of an inclined plane, it will suffice to take for M, not the nominal load of the engine, but its real load; that is to say, not merely the resistance of the wagons, but their resistance *in ascending the inclined plane in question*, as will be seen in Chap. VII. Art. II.

§ 11. *Table of the Volume of the Steam generated under different degrees of Pressure, necessary for the application of the Formulæ.*

The use of the formulæ we have obtained, necessitating a knowledge of the volume of the steam at different degrees of pressure, we subjoin here a table which we have calcuted from 5 to 5 lbs. pressure. The intermediate degrees may be easily filled up; but it would be an unnecessary operation, as we shall see that the pressure in the boiler has so little influence on the speed, that we may, in our calculations, take from the table the pressure nearest to the one we require, provided we also take the volume corresponding with that approximate pressure.

The reason of the little influence the pressure has on the result is, that in proportion as the pressure augments, the volume of the steam diminishes, so that the produce *m*P, that the equation contains, remains constant for such values of P as are very near to each other. We shall very shortly be witnesses of the fact, which will be explained in the calculation we shall make of the velocity of the engine at different pressure.

TABLE OF THE VOLUME OF THE STEAM GENERATED UNDER DIFFERENT PRESSURES.

Total Pressure expressed.		Corresponding temperature by Fahrenheit's thermometer	Volume of the steam compared to the volume of the water that produced it.
In lbs. per square inch.	In atmospheres.		
lbs.		degrees.	
15	1.021	212.6	1,670
20	1.361	227.9	1,282
25	1.701	240.3	1,044
30	2.041	250.8	883
35	2.381	260.0	767
40	2.721	268.1	678
45	3.061	275.4	609
50	3.401	282.0	553
55	3.742	288.1	506
60	4.082	293.8	468
65	4.422	299.1	435
70	4.762	304.0	407
75	5.102	308.7	382
80	5.442	313.1	360
85	5.782	317.3	341
90	6.122	321.3	324
95	6.463	325.1	308
100	6.803	328.8	294

§ 12. *Of the combined Proportions that ought to be given to the parts of an Engine, in order that it may fulfil several conditions at the same time.*

We have given, above, separate from each other, the different practical formulæ of locomotion; but we may also combine those formulæ with one another. To give an example of this, and at the same time a practical application of the results obtained hitherto, we shall suppose that it is required to build an engine capable of drawing a certain given maximum load, and, at the same time, capable of attaining a certain speed, with another load also known.

In this case we may determine the diameter of the cylinder, according to the first condition; and the heating surface of the boiler according to the second. Letting, therefore, M′ be the given maximum load, M″ the second load mentioned above, and V″ the velocity of the engine corresponding with that second load, we shall have simultaneously the two following equations:—(See § 6 and 3.)

$$d = \sqrt{\frac{D\,(9\,M' + F)}{(P - \rho)\,l}}$$

and

$$S = \frac{V''\,[(9 \times M'' + F) + D\,\rho\,d^2\,l]}{(m\,P\,D)}$$

The first equation will give the diameter of the cylinder; and then, introduced in the second equation, it will fix the wanted value of S.

This case is evidently that of a railway on which it would be required that the average trains should have on a level a certain regular speed, and that, at the same time, the engines might ascend with those trains, and without any extra help, an acclivity occurring on a point of the road.

Let us then suppose that it is wanted to build an engine with coupled wheels, capable of drawing a train of 100 gross tons, at a speed of 20 miles an hour on a dead level; and that it is required, at the same time, that that engine be able to ascend without extra aid, and with the same load (reducing, however, its speed,) a plane inclined in the proportion of $\frac{1}{200}$.

We know that an engine working upon a level undergoes, from its load, a certain degree of resistance, which proceeds from the friction of the wagons; but in going up an inclined plane, the load presents not only that same friction of the wagons, but also a surplus of resistance proceeding from the tendency of the train to roll back towards the foot of the plane. The force that draws the train backwards, depends on the weight of the train and on the inclination of the plane. It is the gravity along the plane, and is equal to the mass that is to be moved, divided by the number that marks the inclination of the plane.

On an inclination of $\frac{1}{200}$, the gravity of a weight of 112 t., which is the weight of the train and engine together, is in pounds.

$$\frac{112 \times 2240}{200} = 1254 \text{ lbs.}$$

Now, 1254 lbs.. at the rate of 9 lbs. per ton (including the increase of friction in the engine,) represents the resistance of $\frac{1254}{9} = 139$ t. *on a dead level.* The surplus of resistance occasioned by the inclination of the plane is, therefore, equal to the traction of 139 t. on a level. Consequently, the *total* traction on the rising ground will be 139 t. + 100 t. = 239 t.

Thus, in this case, the load on the inclined plane will be - - - M′ = 239 t. And the load on the dead level M″ = 100 t.

The engine being supposed to weigh 12 t., with coupled wheels, will have a friction of about 180 lbs. If, besides, we suppose it to have a wheel of 5 feet, with a stroke of 16 in. or 1.33 ft.; and if we wish the effective pressure (P — ρ) in the boiler, during the ascent, not to exceed 60 lbs. per square inch, or, in other words, 8640 lbs. per *square foot*, the first equation will give, for the diameter of the cylinder—

$$d = \sqrt{\frac{5\,(9 \times 239 + 180)}{8640 \times 1.33}} = 1 \text{ foot.}$$

Thus the cylinder must have 1 ft. or 12 in. in diameter.

This value must be introduced in the second equation with the other data of the problem. Observing, moreover, that during the journey one may reduce the effective pressure in the boiler to 50 lbs. (or 65 lbs. total pressure) per square inch, which gives for the corresponding volume of the steam m =435 (see the table given in the preceding paragraph,) the second equation will give—

$$S = 20 \times 5280\,\frac{(900+180)\,5 + 2117 \times 1 \times 1.33}{435 \times (65 \times 144) \times 5} = 42.65$$

By which we see that the effective evaporating power S of the engine must be 43 cubic feet of water per hour. And, as we know, by the experiments related above, that the effective power is equal to $\frac{3}{10}$ of the reduced heating surface, this surface must be $43 \times \frac{10}{9} = 143$ square feet.

Finally, this last condition will be fulfilled by giving, for instance, to the fireplace a heating surface of 50 square feet, and to the tubes a surface of 280 square feet.

This example indicates sufficiently the manner in which the calculation is to be made. It would be the same with any other combination that might occur. Evidently, nothing is required but to bring together the different equations concerning the different unknown quantities, and to express that they exist simultaneously.

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ARTICLE VI.

PRACTICAL TABLES OF THE PROPORTIONS AND EFFECTS OF THE ENGINES.

§ 1. *A Practicable Table of the Diameter of the Cylinder and Pressure of Steam, necessary to enable a Locomotive Engine to draw a given Maximum Load.*

We have just calculated, in a special case, the diameter necessary for the cylinder of an engine working at a given pressure, so that it may draw a certain maximum load. In continuing the same calculation through a series of different cases, after the formula § 6, we form the following practical table, which will show either the diameter of the cylinder when the pressure is given, or the pressure in the boiler, when it is the diameter of the cylinder which is determined, or, finally, the maximum load when the two other *data* are fixed beforehand.

It must be understood that the engines will not be able to draw the loads marked in the table, unless the rails are in such a state as to offer a sufficient adhesion to the wheels; without which condition, the movement could not be effected, as will be explained in Chap. VIII.

A PRACTICAL TABLE OF THE DIAMETER OF THE CYLINDER AND PRESSURE OF STEAM CORRESPONDING TO GIVEN MAXIMUM LOADS.

DESCRIPTION OF THE ENGINE.	Max. load in gross tons tender includ.	Diameter of the Cylinder, in inches, the pressure per square inch in the Boiler being				
		50 lbs.	55 lbs.	60 lbs.	65 lbs.	70 lbs.
	tons.	in.	in.	in.	in.	in.
Engine with wheel - - 5 ft.	100	8.8	8.4	8.0	7.7	7.4
Stroke of the piston 16 in. or 1.33 ft.	125	9.7	9.2	8.8	8.5	8.2
	150	10.5	10.0	9.6	9.2	8.9
Weight - - - 8 tons.	175	11.3	10.8	10.3	9.9	9.5
or presumed friction - 120 lbs.	200	12.0	11.5	11.0	10.5	10.2
	225	12.7	12.1	11.6	11.1	10.7
	250	13.4	12.7	12.2	11.7	11.3
Engine with wheel - 5 ft.	200	12.2	11.6	11.1	10.7	10.3
Stroke of the piston, 16 in. or 1.33 ft.	225	12.9	12.3	11.8	11.3	10.9
	250	13.5	12.9	12.3	11.9	11.4
Weight, - - - 12 tons.	275	14.1	13.5	12.9	12.4	11.9
or presumed friction - 180 lbs.	300	14.7	14.0	13.4	12.9	12.4
	325	15.3	14.6	14.0	13.4	12.9
	350	15.8	15.1	14.4	13.9	13.4
Engine with wheel - - 5 ft.	200	11.5	10.9	10.5	10.0	9.7
Stroke of the piston 18 in. or 1.50 ft.	225	12.1	11.5	11.0	10.6	10.2
	250	12.7	12.1	11.6	11.1	10.7
Weight - - - 11 tons.	275	13.3	12.7	12.1	11.6	11.2
or presumed friction - 165 lbs.	300	13.8	13.2	12.6	12.1	11.7
	325	14.4	13.7	13.1	12.6	12.1
	350	14.9	14.2	13.6	13.0	12.6

§ 2. *A Practical Table of the length of Stroke of the Piston, and Diameter of Wheel, necessary to enable an Engine to draw a fixed Maximum Load at a given Pressure.*

In solving the formula § 7, in a series of cases adapted to the engines the most in use, the following table is formed, which will show, at first sight, either the length of stroke of the piston, or the diameter of the wheel which an engine ought to have, for it to draw a maximum load at a given pressure; or, again, the maximum loads corresponding to given dimensions for the length of stroke of the piston and diameter of the wheel.

A PRACTICAL TABLE OF THE LENGTH OF STROKE AND DIAMETER OF WHEEL, CORRESPONDING TO GIVEN MAXIMUM LOADS.

Description of the Engine.	Maximum load in gross tons, tender included.	Length of Stroke, in inches, the diameter of the wheel being			
		3 ft.	4 ft.	5 ft.	6 ft.
	tons.	in.	in.	in.	in.
Engine with cylinders 11 in. or 0.917 ft.	150	8.7	11.7	14.6	17.5
Weight - - - - - - - - 8 tons.	175	10.1	13.4	16.8	20.2
or presumed friction - 120 lbs.	200	11.4	15.2	19.0	22.8
Effective pressure per sq.	225	13.8	17.0	21.3	25.5
inch in the boiler - - 50 lbs.	250	14.1	18.8	23.5	28.2
Engine with cylinders 12 in. or 1 ft.	200	9.8	13.0	16.3	19.5
Weight - - - - - - - 10 tons.	225	10.9	14.5	18 1	21.8
or presumed friction - 150 lbs.	250	12.0	16.0	20.0	24.0
Effective pressure per sq.	275	13.1	17.5	21.9	26.3
inch in the boiler - - 50 lbs.	300	14.3	19.0	23.8	28.5
Engine with cylinders 13 in. or 1.083 ft.	200	8.4	11.2	14.0	16.8
Weight - - - - - - - 11 tons.	225	9.3	12.5	15.6	18.7
or presumed friction - 165 lbs.	250	10.3	13.7	17.2	20.6
Effective pressure per sq.	275	11.3	15.0	18.8	22.5
inch in the boiler - - 50 lbs.	300	12.2	16.3	20.4	24.4
	325	13.2	17.6	22.0	26.4
	350	14.1	18.8	23.6	28.3
Engine with cylinders 14 in. or 1.166 ft.	250	8.9	11.9	14.9	17.9
Weight - - - - - - - 12 tons.	275	9.8	13.0	16.3	19.5
or presumed friction - 180 lbs.	300	10.6	14.1	17.7	21.2
Effective pressure per sq.	325	11.4	15.2	19.0	22.8
inch in the boiler - - 50 lbs.	350	12.3	16.3	20.4	24.5
	375	13.1	17.4	21.8	26.2
	400	13.9	18.5	23.2	27.8

§ 3. *A Practical Table of the Area of Heating Surface capable of producing a given Velocity with given Loads.*

In order to faciliate practical researches, we shall extend, to a certain number of the most ordinary cases, the calculation of the heating surface capable of producing predetermined effects.

The table which we are thus going to form after the formula in § 3, may serve, not only to determine the heating surface capable of producing desired effects, but also the velocity of given loads, when the heating surface is already determined.

The table supposes the engine working at 50 lbs. effective pressure, per square inch, in the boiler. As, however, the pressure has no perceptible influence on the velocity, as will be seen hereafter, if the engine works at a higher pressure, it will be able to attain a more considerable maximum load; but for all the loads of the table, it will, nevertheless, require the same heating surface in order to produce the same velocity. In consequence, the table may serve for any pressure, either above or below 50 lbs. The only difference will be in the maximum loads, which, agreeable to the pressure, will be greater or smaller than those fixed in the table.

By recurring to § 10 of the preceding Article, it will be seen in what manner the area of heating-surface is to be computed.

A PRACTICAL TABLE OF THE HEATING-SURFACES CAPABLE OF PRODUCING A GIVEN VELOCITY WITH GIVEN LOADS.

DESCRIPTION OF THE ENGINE.	Load in gross tons, tender included	Area of heating-surface of the boiler, in square feet the desired velocity in miles per hour being				
		10 miles.	15 miles.	20 miles.	25 miles.	30 miles.
	tons.	sq. ft.	sq. ft.	sq. ft.	sq. ft.	sq. ft.
Engine with wheel - - - - 5 ft.	25	36	54	71	89	107
Stroke of the piston 16 in. or 1.33 ft.	50	46	68	91	113	136
Cylinders 11 inches, or - 0.917 ft.	75	55	83	110	138	165
Weight - - - - - - - 8 tons.	100	65	97	130	162	194
or presumed friction - 120 lbs.	125	75	112	149	186	223
Effective pressure per sq.	150	84	126	168	210	252
inch in the boiler - - - 50 lbs.	165	90	135	180	225	...
Engine with wheel - - - - 5 ft.	50	51	76	101	126	151
Stroke of the piston 16 in. or 1.33 ft.	75	60	90	120	150	180
Cylinders, 12 inches, or - - 1 ft.	100	70	105	140	175	210
Weight - - - - - - - 10 tons.	125	80	120	159	199	239
or presumed friction - - 150 lbs.	150	90	134	179	223	268
Effective pressure per sq.	175	99	149	198	248	297
inch in the boiler - - - 50 lbs.	196	107	161	215	268	...
Engine with wheel - - - - 5 ft.	50	56	83	111	138	166
Stroke of the piston 16 in. or 1.33 ft.	75	65	98	130	163	195
Cylinders 13 inches, or - - 1.083 ft.	100	75	112	150	187	224
Weight - - - - - - - 11 tons.	125	85	127	169	211	253
or presumed friction - - 165 lbs.	150	94	141	188	235	282
Effective pressure per sq.	175	104	156	208	260	...
inch in the boiler - - - 50 lbs.	200	114	171	227	284	...
	225	124	185	247	...	...
	231	126	189	251	...	...
Engine with wheel - - - - 5 ft.	50	61	91	121	151	181
Stroke of the piston 16 in. or 1.33 ft.	75	70	106	141	176	211
Cylinders 14 inches, or - - 1.166 ft.	100	80	120	160	200	240
Weight - - - - - - - 12 tons.	125	90	135	180	224	269
or presumed friction - - 180 lbs.	150	100	149	199	249	298
Effective pressure per sq.	175	109	164	218	273	...
inch in the boiler - - - 50 lbs.	200	119	178	238	297	...
	225	129	193	257	...	...
	250	139	208	277	...	...
	269	146	219	291	...	...
Engine with wheel - - - - 5 ft.	50	62	92	123	153	184
Stroke of the piston 18 in. or 1.50 ft.	75	71	107	142	178	213
Cylinders 12 inches, or - - 1 ft.	100	81	121	162	202	242
Weight - - - - - - - 11 tons.	125	91	136	181	226	271
or presumed friction - - 165 lbs.	150	100	151	201	251	301
Effective pressure per sq.	175	110	165	220	275	...
inch in the boiler - - - 50 lbs.	200	120	180	239	299	...
	221	128	192	256	...	...

4. § *A practical Table of the Velocity of Engines with given Loads, and, vice versa, of the Load corresponding to a given Velocity.*

We have just given some examples of cases, in which it is wished to build an engine for a particalar end. The contrary case naturally presents itself afterwards. The question is, what effect may be expected from a given engine, that is to say, from an engine already constructed, and the dimensions of which can be measured.

In order to give here a practical and extensive application of the formulæ which resolve this question, we shall calculate, after the formula, § 1, a table of the velocity which engines, similar to those of Liverpool, viz. with 11 and 12 in. cylinders, will acquire with given loads. By that means, the experiments, which we are going to make on the Liverpool engines, will serve to verify, *by facts*, the accuracy of the formulæ, which we have deduced from principle.

As we think that this table, like the preceding ones, may be useful to practical men, in showing them the results, without obliging them to make the calculation, we shall extend it further to engines of different powers, such as are most in use on railways.

It will be remarked, that this table, giving the velocity corresponding to known loads, naturally furnishes also the loads of the engine, when, on the contrary, the velocity is given *a priori*. In like manner, as we have necessarily been obliged to confine ourselves, in each column, to the limit of load which the engine is capable of drawing at the pressure indicated, after the formula in § 4; so it follows that the same table gives equally the maximum loads for each pressure, as well as their correspond. ing velocity.

In the last column, the state of the regulator is indicated as follows: when it is entirely open, we write 1; when only half open, $\frac{1}{2}$; etc. This relates to the following tables, as well as to this one:

A PRACTICAL TABLE OF THE VELOCITY OF THE ENGINES WITH GIVEN LOADS, AND OF THE LOAD CORRESPONDING TO A GIVEN VELOCITY.

Description of the engine.	Load in gross tons tender included.	Velocity on a level in miles per hour, the effective pressure per sq. in. in the boiler being			State of the regulator.
		50 lbs.	55 lbs.	60 lbs.	
	tons.	miles.	miles.	miles.	
Engine with cylinders 11 in. or 0.917 ft.	25	40.07	40.38	40.60	1
Stroke of the piston 16 in., or 1.33 ft.	50	31.34	31.58	31.76	1
Wheel - - - - - - - 5 ft.	75	25.74	25.93	26.06	1
Friction - - - - - 110 lbs.	100	21.83	22.00	22.12	1
Area of heating surface 140 sq. ft.	125	18.96	19.10	19.21	1
Or effective evaporating	150	16.75	16.88	16.97	1
power per hour - - 42 cu. ft.	166	15.59	15.71	15.80	1
	175	...	15.12	15.21	1
	184	...	14.58	14.66	1
	202	...	...	13.67	1
Engine with cylinders 12 in., or 1 ft.	25	34.48	34.71	34.91	1
Stroke of the piston 16 in., or 1.33 ft.	50	27.80	28.01	28.16	1
Wheel - - - - - - - 5 ft.	75	23.29	23.47	23.60	1
Friction - - - - - - 152 lbs.	150	20.05	20.21	20.32	1
Area of heating surface 140 sq. ft.	125	17.60	17.73	17.83	1
Or effective evaporating	150	15.58	15.80	15.89	1
power per hour - - 42 cu. ft.	175	14.14	14.25	14.33	1
	195	13.11	13.21	13.28	1
	200	...	12.98	13.05	1
	217	...	12.23	12.30	1
	255	...	...	10.91	1
Engine with cylinders 13 in., or 1.083 ft.	50	29.03	29.25	29.42	1
Stroke of the piston 16 in., or 1.33 ft.	75	24.68	24.86	25.00	1
Friction - - - - - - 165 lbs.	100	21.46	21.62	21.74	1
Area of heating surface 160 sq. ft.	125	18.98	19.13	19.23	1
Or effective evaporating	150	17.02	17.15	17.24	1
power per hour - - 48 cu. ft.	175	15.42	15.54	15.63	1
	200	14.10	14.21	14.29	1
	225	12.99	13.09	13.16	1
	231	12.75	12.84	12.92	1
	256	...	11.92	11.99	1
	281	...	...	11.18	1
Engine with cylinders 14 in., or 1.166 ft.	50	29.83	30.06	30.22	1
Stroke of the piston 16 in., or 1.33 ft.	75	25.69	25.88	26.03	1
Friction - - - - - - 180 lbs.	100	22.56	22.73	22.86	1
Area of heating surface 180 sq. ft.	125	20.11	20.26	20.37	1
Or effective evaporating	150	18.14	18.28	18.38	1
power per hour - - 54 cu. ft.	175	16.52	16.64	16.74	1
	200	15.17	15.28	15.37	1
	225	14.02	14.12	14.20	1
	250	13.03	13.13	13.20	1
	269	12.37	12.46	12.53	1
	298	...	11.57	11.63	1
	327	...	...	10.85	1
Engine with cylinders 12 in., or 1 ft.	50	26.16	26.36	26.51	1
Stroke of the piston 18 in., or 1.50 ft.	75	22.57	22.74	22.87	1
Friction - - - - - - 165 lbs.	100	19.85	20.00	20.11	1
Area of heating surface 160 sq. ft.	125	17.71	17.85	17.95	1
Or effective evaporating	150	15.99	16.11	16.20	1
power per hour - - 48 cu. ft.	175	14.57	14.68	14.77	1
	200	13.39	13.49	13.56	1
	221	12.53	12.63	12.70	1
	246	...	11.73	11.80	1
	270	...	...	11.05	1

We remark here, as we have said above, that the whole influence of the pressure bears upon the limit of the load, but that its effect is almost insensible on the velocity. This result agrees with the principle; for if the pressure required on the piston to move the load, be, for instance, 46 lbs. per square inch, is it not true that, provided the steam be abundantly furnished at that pressure, by the heating surface, it is of little consequence whether it be at first collected in the boiler at a pressure of 75 lbs. or 65 lbs. or at any other degree? Finally, at the moment of acting, it must any how be transformed into steam at 46 lbs. pressure, and the speed will depend solely on the quantity of steam at 46 lbs. that the boiler will have furnished. The small advantage we observe here in favor of a greater pressure is only owing to the fire being in that case naturally more intense; a circumstance from which results, not that there is more water evaparated, but the same quantity, notwithstanding a higher pressure.

These tables show the effect that may be expected from an engine of given proportions, in regard either to the speed or to the load; but it is understood that the effect can only be produced if the engine is put in a situation to apply all its power.

If, for instance, instead of the fire being sufficiently animated, it is left to languish, the quantity of water evaporated per minute will be diminished, and at the same time the effect of the engine,

If the engine, instead of being in good order, loses its steam, either by leaks in the boiler, or round the piston, or by the stuffing boxes, or elsewhere, it is clear that the effect must also be proportionately diminished.

If, by diminishing the opening of the regulator, we let only a portion of the generated steam penetrate into the cylinders, the boiler continuing at first to furnish the same quantity, more steam will necessarily be lost by the valves without acting on the pistons. Afterwards, as soon as the diminution of the steam thrown into the chimney has moderated the fire, there will be less steam generated, and that will consequently regulate the velocity. This is the case of all small loads drawn by the engines. The speed is never suffered to augment sufficiently to risk an accident by too rapid a motion of the piston or other parts of the mechanism. When the engine-men perceive that the train would run too fast, they diminish the aperture of the regulator, and make a moderate fire, in order to maintain a reasonable speed. In all the experiments we shall have occasion to relate below, we shall only once see, as we have already observed, the speed rise to 35 miles an hour, which is the greatest speed to which the engines have been hitherto submitted, excepting for a very short instant.

In the above tables, the limits of load of the engines, with the indicative pressure, are fixed by the necessity of the resistance on the piston not being greater than the force that must move it, as we have already said. With that maximum load, we see that an eleven-inch cylinder engine, working at 60 lbs. effective pressure, will still maintain a velocity of 13½ miles; and a twelve-inch cylinder engine, with an effective pressure of 55 lbs., will still maintain a speed of 12 miles an hour. These velocities are those which will take place if the engine works in its right state; that is to say, if the valve is fixed for a pressure of 60 lbs. or 55 lbs. But if it should happen that the valve be only regulated for a pressure of 50 lbs., and the pressure of 60 lbs. or 55 lbs. be produced by an extraordinary rising of the valve and by dint of losing steam, that is to say, only because the steam above 50 lbs. cannot escape as quickly as it is generated, then it is clear that although the evaporating power of the boiler remains the same, the effective part of that power will be considerably reduced, and, consequently, also the velocity. It is for that reason that, in the experiments, we shall see the speed go sometimes down to two or three miles an hour. But the state of the valve must then be observed. The elevated pressure will be seen to be produced only by an enormous loss of steam, and it will be easy, by the rising of the valve, to account for the diminution of speed.

In the cases of *maximum* load, it is evident that the steam will be spent by the cylinder, at the same pressure at which it has been generated in the boiler, and that the peed of the piston will be equal to the uickness with which the steam is generatd. This fact has been proved in a genral manner in § 5 of the present article.

It may be verified here by calculating the velocity with which the quantity of steam, generated in a minute, would cross the cylinders without any alteration or reduction of pressure. The velocity of the engine resulting from it, will be found to coincide exactly with that indicated in the table. This is a proof that, in case the engine only advances at that speed, the pressure in the cylinder is equal to that in the boiler.

Those cases of limit roads are those of which we have made use to determine the friction of the loaded engine, and we see here the principle justified, of which we then made use, viz. that in case the speed of these engines is under 12 miles an hour, the pressure in the cylinder is the same as in the boiler.

We have one observation more to make, which is, that in the engines there always exists a small loss, which we have not taken into account in our calculation; that is to say, the loss of the steam which, at each stroke of the piston, fills the passages that lead from the slides to the cylinders. It would be easy to take it into account, by the measures taken on each engine, of the diameter and length of these passages; but this loss is very insignificant, and would only complicate the calculation without any advantage.

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ARTICLE VII.

CONFIRMATION OF THE ABOVE FORMULÆ BY EXPERIMENTS.

§ 1. *Experiments on the Velocity and Load of the Engines.*

As a verification of the formulæ we have laid down, and with a view to enable our readers to rest their calculations on material facts, we shall give here a series of experiments undertaken by us, in order to ascertain the speed with which the engines draw different loads at different degrees of pressure of the steam, in their daily and regular work.

These experiments were made on the Liverpool and Manchester Railway, the section of which, according to a levelling made in the month of August 1833, by Mr. Dixon, resident engineer, is as follows. We only give the part travelled over by the locomotive engines; there are, besides, under the city of Liverpool, three tunnels worked by separate stationary steam engines.

The railway, on leaving the station at Liverpool, until it terminates at Manchester, passes over the following distances and slopes:

Miles.			
0.53	dead level.		
5.23	descent - - -	at	$\frac{1}{1094}$
1.47	ascent - - -	at	$\frac{1}{96}$
1.87	dead level.		
1.39	descent - - -	at	$\frac{1}{80}$
2.41	descent - - -	at	$\frac{1}{274\frac{1}{2}}$
6.60	descent - - -	at	$\frac{1}{844}$
5.62	ascent - - -	at	$\frac{1}{1300}$
4.36	ascent - - -	at	$\frac{1}{4287}$
29.48	miles.		

From these different inclinations, we see that the same train presents various degrees of resistance, according to the part of the road travelled over, because the gravity of the total mass in motion becomes an alleviation in the descents, and an additional obstacle in the rising ground.

The result is, that a train of 100 t., offers on a dead level a resistance of 800 lbs.; besides the friction of the engine; and that the same train, if it is, for instance, drawn by an engine weighing 10 t., will, on arriving at an ascent of $\frac{1}{96}$, offer a resistance of 3,366 lbs., which upon a dead level would be equal to the resistance of a train of 421 t.

In fact, if we observe that a ton weighs 2,240 lbs., we shall find for the resistance:

100×8 lbs. = 800 lbs.; resistance owing to the friction.

$\frac{100 \times 2{,}240 \text{ lbs.}}{96}$ = 2,333 lbs. resistance owing to the gravity of the train, on a plane inclined at $\frac{1}{96}$.

$\frac{10 \times 2{,}240 \text{ lbs.}}{96}$ = 233 lbs. similar resistance owing to the gravity of the engine.

3,366 lbs. total resistance, (not including the friction of the engine,) equal to that of a load of $\frac{3366}{8}$ = 421 t. on a level.

That is the manner in which we have calculated the real load of the engine on the different slopes it had to pass over during its journey.

The following column marks the pressure in the boiler, expressed first by the state of the balance, and then by its equivalent on the mercurial gauge. Thus, when the balance, fixed at 57, rose by the blowing to 58, we have written 57—58; and as for the ATLAS, for instance, that state of the balance corresponds with an effective pressure by the mercurial gauge of 61 lbs., we have written 57—58 = 61 lb.

We have also noted the state of the regulator; but we must add, that the handle of the regulator in these engines not turning on a graduated circle, as it would be better that it should, we have only been able to estimate the degree of opening of the regulator at sight and by approximation.

The speeds have been carefully taken down, by inscribing in minutes and quarters of minute the time when the engine passed before every quarter-mile stone of the road. These stones are numbered all along the way. At the same moment we noted the pressure in the boiler as marked on the valve balance.

The weight of the wagons was taken *exactly* in tons, cwts., quarters, and pounds. The tender cartwrights were not weighed, but they are reckoned at their average weight of 5½ t. when a fresh supply of water is taken in on the road, and 5 t. only in the contrary case.

We have marked the state of the weather, because it is a known fact that with the wind a-head, and still more with a side-wind that presses the flange of the wheels against the rails, the resistance of the train is augmented. Finally we have also mentioned the temperature of the water in the tender, in order that the reader may judge of the influence of that circumstance; and we have given the date of each of the experiments as a means of verification.

(To be Continued.)

I witnessed at the capitol with great pleasure on Monday last, Mr. Smith Cram's (of the city of New-York) invention for overcoming an elevation in Railroad transportation of 440 feet to the mile. It was performed with expedition by a single stroke perpendicular engine, which in point of power suffers much in comparison with a double stroke Locomotive Engine.

His plan, as exhibted, puts at rest all doubt as to the practicability of ascending and descending hills from 450 to 600 feet to the mile, with certainty and security. As to the certainty of overcoming elevation and inclination, the cog-wheels and ratchets as arranged satisfactorily show. As to the security, it is to be found in the introduction of his hydrostatic cylinder attached to the car which is designed to check the train of cars in ascending should any accident befal the engine, and to regulate their velocity in descending, or check them altogether. The accuracy of the principle in both cases is perfectly clear, and promises to be of incalculable value in the present age of improvement; and I doubt not it will be generally adopted upon the score of economy as to time and money; but above all in the preservation of human life, which his plan so effectually guarantees, in comparison with the present mode of overcoming a trifling elevation by stationary power, committing our lives to the hazard of a single rope.

FULTON.

NOTICE TO RAILROAD CONTRACTORS.

THE First Division of the BANGOR and OLD TOWN RAILROAD, extending from Bangor to Stillwater, will be ready for contract by the 15th inst., and sealed proposals will be received for the grading, masonry and bridging the same until the 25th inst., at the office of the subscriber in Bangor.

JOSHUA BARNEY, Engineer.

Bangor, June 2, 1836. 22—2t

TO CONTRACTORS.

PROPOSALS will be received at the Office of the Eastern Railroad Company, Boston, between the 28th and 30th inst., for the grading and masonry of said Road from East Boston to Newburyport, a distance of 33¾ miles

The line of this road is along a favorable country, passing threugh Lynn, Salem, Beverly, and Ipswich, which places will afford contractors every facility for obtaining provisions, &c. Plans and Profiles will be ready, and may be seen at the Office, after the 22d instant.

Satisfactory recommendations must accompany the proposals of those who are unknown to the Engineer.

22—t30] JOHN M. FESSENDEN, Engineer.

NOTICE TO CONTRACTORS.

JAMES RIVER AND KANAWHA CANAL.

PROPOSALS will be received at the Office of the James River and Kanawha Company, in the City of Richmond, from the 15th to the 23rd day of August, for the construction of all the Excavation, Embankment and Walling not now under contract, together with nearly all the Culverts and the greater portion of the Locks between Lynchburg and Maidens' Adventure.

The work now advertised embraces the twenty miles between Columbia and the head of Maidens' Adventure Pond, the eight miles between Seven Island Falls and Scottsville, and about twenty isolated sections, reserved at the former letting, between Scottsville and Lynchburg.

The quantity of masonry offered is very great—consisting of about two hundred Culverts of from three to thirty feet span; nine Aqueducts, thirty-five Locks a number of Wastes, with several farm and road Bridges.

General plans and specifications of all the work, and special plans of the most important Culverts and Aqueducts, will be found at the offices of the several Principal Assistant Engineers on the line of the Canal.

The work will be prepared for examination by the 25th July; but mechanics, well recommended, desirous of immediate employment, can obtain contracts for the construction of a number of Culverts at private letting.

Persons offering to contract, who are unknown to the subscriber, or any of the Assistant Engineers, will be expected to accompany their proposals by the usual certificates of character and ability.

CHARLES ELLET, Jr.,
Chief Engineer of the James River and Kanawha Company.

NOTE.—The Dams, Guard-Locks, most of the Bridges, and a number of Locks and Culverts, are reserved for a future letting. Persons visiting the line for the purpose of obtaining work, would do well to call at the office of the Company in the city of Richmond, where any information which they may desire will be cheerfully communicated.

The valley of James River, between Lynchburg and Richmond, is healthy. (20—ta18) C. E. Jr.

RAILROAD CAR WHEELS AND BOXES, AND OTHER RAILROAD CASTINGS.

Also, AXLES furnished and fitted to wheels complete at the Jefferson Cotton and Wool Machine Factory and Foundry, Paterson, N. J. All orders addressed to the subscribers at Paterson, or 60 Wall street, New-York, will be promptly attended to.

Also, CAR SPRINGS.

Also, Flange Tires, turned complete.

J8 ROGERS, KETCHUM & GROSVENOR.

ALBANY EAGLE AIR FURNACE AND MACHINE SHOP.

WILLIAM V. MANY manufactures to order, IRON CASTINGS for Gearing Mills and Factories of every description.

ALSO—Steam Engines and Railroad Castings of every description.

The collection of Patterns for Machinery, is not equalled in the United States. 9—1y

RAILWAY IRON.

95 tons of 1 inch by		½ inch.	FLAT BARS in lengths
200	do	1½	do	½	do	of 14 to 15 feet, counter
40	do	1¼	do	½	do	sunk holes, ends cut at
800	do	2	do	½	do	an angle of 45 degrees,
800	do	2½	do	½	do	with splicing plates and
soon expected.						nails to suit.

250 do. of Edge Rails of 36 lbs. per yard, with the requisite chairs, keys, and pins.

Wrought Iron Rims of 30, 33, and 36 inches diameter for Wheels of Railway Cars, and of 60 inches diameter for Locomotive Wheels.

Axles of 2½, 2¾, 2⅞, 3, 3⅛, 3¼, and 3½ inches in diameter, for Railway Cars and Locomotives, of patent iron.

The above will be sold free of duty, to State Governments and Incorporated Governments, and the drawback taken in part payment.

A. & G. RALSTON,
9 South Front street, Philadelphia.

Models and samples of all the different kinds of Rails, Chairs, Pins, Wedges, Spikes, and Splicing Plates, in use both in this country and Great Britain, will be exhibited to those disposed to examine them. 4—d7 1meowr

STEPHENSON,

Builder of a superior style of Passenger Cars for Railroads.

No. 264 Elizabeth street, near Bleecker street, New-York.

RAILROAD COMPANIES would do well to examine these Cars; a specimen of which may be seen on that part of the New-York and Harlaem Railroad now in operation. J25tf

FRAME BRIDGES.

THE subscriber would respectfully inform the public, and particularly Railroad and Bridge Corporations that he will build Frame Bridges, or vend the right to others to build, on Col. Long's Patent, throughout the United States, with few exceptions. The following sub-Agents have been engaged by the undersigned who will also attend to this business, viz.

Horace Childs,	Henniker, N. H.
Alexander McArthur,	Mount Morris, N. Y.
John Mahan,	do do
Thomas H. Cushing,	Dover, N. H.
Ira Blake,	Wakefield, N. H.
Amos Whitemore, Esq.,	Hancock, N. H.
Samuel Herrick,	Springfield, Vermont.
Simeon Herrick,	do do
Capt. Isaac Damon,	Northampton, Mass.
Lyman Kingsly,	do do
Elijah Halbert,	Waterloo, N. Y.
Joseph Hebard,	Dunkirk, N. Y.
Col. Sherman Peck,	Hudson, Ohio.
Andrew E. Turnbull,	Lower Sandusky, Ohio.
William J. Turnbull,	do do
Sabried Dodge, Esq.,	(Civil Engineer,) Ohio.
Booz M. Atherton, Esq.	New-Philadelphia, Ohio.
Stephen Daniels,	Marietta, Ohio
John Rodgers,	Louisville, Kentucky.
John Tililson,	St. Francisville, Lous'a.
Capt. John Bottom,	Tonawanda, Penn.
Nehemiah Osborn,	Rochester, N. Y.

Bridges on the above plan are to be seen at the following localities, viz. On the main road leading from Baltimore to Washington, two miles from the former place. Across the Metawamkeag river on the Military road, in Maine. On the National road in Illinois, at sundry points. On the Baltimore and Susquehanna Rrailroad at three points. On the Hudson and Patterson Railroad, in two places. On the Boston and Worcester Railroad, at several points. On the Boston and Providence Railroad, at sundry points. Across the Contocook river at Hancock, N. H. Across the Connecticut river at Haverhill, N. H. Across the Contoocook river, at Henniker, N. H. Across the Souhegan river, at Milford, N. H. Across the Kennebec river, at Waterville, in the state of Maine.—Across the Genesse river, at Mount Morris, New-York, and several other bridges are now in progress.

The undersigned is about to fix his residence in Rochester, Monroe country, New-York, where he will promptly attend to orders in this line of business to any practicable extent in the United States, Maryland excepted. MOSES LONG.

General Agent of Col. S. H Long.
Rochester, May 22d, 1836. 19y-tf.

PATENT RAILROAD, SHIP AND BOAT SPIKES.

☞ The Troy Iron and Nail Factory keeps constantly for sale a very extensive assortment of Wrought Spikes and Nails, from 3 to 10 inches, manufactured by the subscriber's Patent Machinery, which after five years successful operation, and now almost universal use in the United States, (as well as England, where the subscriber obtained a patent,) are found superior to any ever offered in market.

Railroad Companies may be supplied with Spikes having countersink heads suitable to the holes in iron rails, to any amount and on short notice. Almost all the Railroads now in progress in the United States are fastened with Spikes made at the above named factory—for which purpose they are found invaluable, as their adhesion is more than double any common spikes made by the hammer.

*** All orders directed to the Agent, Troy, N. Y., will be punctually attended to.

HENRY BURDEN, Agent.
Troy, N. Y., July, 1831.

*** Spikes are kept for sale, at factory prices, by I. & J. Townsend, Albany, and the principal Iron Merchants in Albany and Troy; J. I. Brower, 222 Water street, New-York; A. M. Jones, Philadelphia; T. Janviers, Baltimore; Degrand & Smith, Boston.

P. S.—Railroad Companies would do well to forward their orders as early as practicable, as the subscriber is desirous of extending the manufacturing so as to keep pace with the daily increasing demand for his Spikes.

1J23am H. BURDEN.

ARCHIMEDES WORKS.

(100 North Moor street, N. Y.)

NEW-YORK, February 12th, 1836.

THE undersigned begs leave to inform the proprietors of Railroads that they are prepared to furnish all kinds of Machinery for Railroads, Locomotive Engines of any size, Car Wheels, such as are now in successful operation on the Camden and Amboy Railroad, none of which have failed—Castings of all kinds, Wheels, Axles, and Boxes, furnished at shortest notice.

4—ytf H. R. DUNHAM & CO.

PROSPECTUS

OF VOLUME II. OF THE

CHICAGO AMERICAN,

TO BE PUBLISHED SEMI-WEEKLY.

In proposing to establish a SEMI-WEEKLY paper under the old title, but with extended dimensions, the subscriber acknowledges the favors of the past, and solicits the continued patronage of a liberal public.—The reasons that induced him about a year since to establish his weekly paper, operates with renewed and increasing force in favor of his present design.—He shall endeavor, as it was originally intended, to make his paper American in all things; and by identifying itself with the interests and circumstances of Chicago—which from a recent wildnerness has advanced to a population of thirty-five hundred—and of the rich, extensive, and rapidly developing country of which it is the emporium, he hopes it may "grow with their growth, and strengthen with their strength."

As a record of passing events, current literature, of the march of agriculture, commerce and manufactures, and especially of the progress of internal improvements, of which this State, by her recent passage of the act for the construction of the "Illinois and Michigan Canal," has commenced her great and auspicious system, it will aim, as ever, to be accurately and early informed, and thus endeavor to consult alike the tastes and wants of the community with which it is identified. With party, as generally understood, it will have as little to do as possible. Its politics will be the Constitution—its party, the Country.

With this brief explanation of its future course, and his thanks for the more than expected encouragement he has already received, the subscriber again ventures to solicit the continued patronage and extended support of all who may feel an interest in the principles here set forth.

It will be enlarged and otherwise greatly improved, and printed on superior paper, and forwarded to distant subscribers by the earliest mails, enveloped in a strong wrapper.

TERMS.—The AMERICAN will be published SEMI-WEEKLY, at $4 per annum, if paid at the time of subscribing; $5 if paid at the expiration of six months, or $6 if payment is delayed to the end of the year.

*** Any person procuring five subscribers and remitting the pay in advance, will be entitled to a sixth copy gratis, or a deduction of TEN PER CENT.

Persons at a distance remitting a $5 bill will receive the paper fifteen months.

*** All sums to the amount of $10 and upwards may be sent through the Post Office, at my expense.

THOS. O. DAVIS.

Chicago, March 25, 1836.

*** Subscriptions and Advertisements for the CHICAGO AMERICAN will be received at the Office of the Railroad Journal, 132 Nassau street, by

D. K. MINOR.

☞ THE NEWCASTLE MANUFACTURING COMPANY, incorporated by the State of Delaware, with a capital of 200,000 dollars, are prepared to execute in the first style and on liberal terms, at their extensive Finishing Shops and Foundries for Brass and Iron, situated in the town of Newcastle, Delaware, all orders for LOCOMOTIVE and other Steam Engines, and for CASTINGS of every description in Brass or Iron RAILROAD WORK of all kinds finished in the best manner, and at the shortest notice.

Orders to be addressed to

MR. EDWARD A. G. YOUNG,
Superintendent, Newcastle, Delaware.
feb 20—ytf

NOTICE OF THE NEW-YORK AND ERIE RAILROAD COMPANY.

THE Company hereby withdraw their Advertisement of 26th April, in consequence of their inability to prepare in time, the portions of the line proposed to be let on the 30th June, at Binghampton, and on the 11th of July at Monticello. Future notice shall be given, when proposals will be received at the above places, for the same portions of the road.

21—tf JAMES G. KING, President.

AMES' CELEBRATED SHOVELS, SPADES, &c.

300 dozens Ames' superior back-strap Shovels			
150	do	do	do plain do
150	do	do	do cast steel Shovels & Spades
150	do	do	Gold-mining Shovels
100	do	do	plated Spades
50	do	do	socket Shovels and Spades.

Together with Pick Axes, Churn Drills, and Crow Bars (steel pointed,) manufactured from Salisbury refined iron—for sale by the manufacturing agents,

WITHERELL, AMES & CO.
No. 2 Liberty street, New-York.
BACKUS, AMES & CO.
No. 8 State street, Albany.

N. B.—Also furnished to order, Shapes of every description, made from Salisbury refined Iron. 4—ytf